

SIGNAL STRENGTH MONITOR FOR C-SPAD RECEIVER

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Abstract

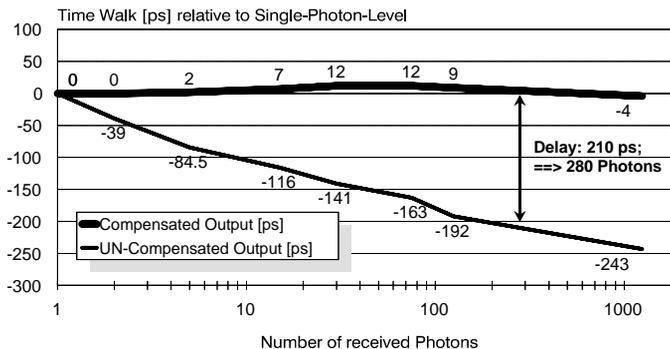
We are reporting on the possibility of echo signal strength monitoring in the C-SPAD based laser ranging systems. The operating principle and the experimental results will be presented. The Signal Strength Monitor SSM has been incorporated into the Portable Pico Event Timer 2k. The stand-alone electronics device has been designed, it determines the photon number estimate in a receiver chain based on C-SPAD detector package. The device is interfaced to a station computer via conventional serial link.

Goals:

- to estimate the echo signal strength in laser ranging based on C-SPAD detector
- the SPAD chip current pulse risetime depends on photon number (*Kirchner, Koidl, 1995*)
- C-SPAD circuit provides two output timing pulses, their interval corresponds to the detected signal energy
- to construct the Time to Digital Converter to record the interval and hence the echo signal energy

C-SPAD Detector Package # 0406

Measured: Delay (Comp-Uncomp Output) with PPET



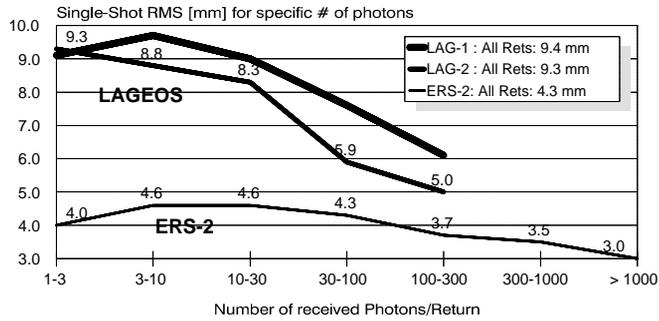
<Graz, 1998-08-26>

- avalanche build up time effect expanded by built-in circuit (*G.Kirchner, F.Koidl*)
- large data sets averaging

SLR with Photon Number Estimate

RMS vs. Received # of Photons

Rec. Energy: Meas. by PPET (Compens.Delay)



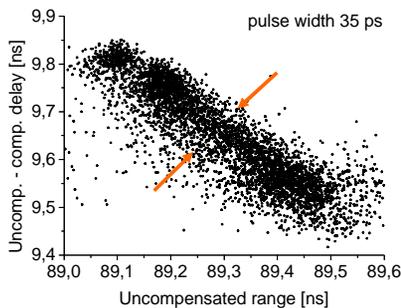
<Graz, 1998-09-11>

G. KIRCHNER¹⁾, F. KOIDL¹⁾, I. PROCHAZKA²⁾, K. HAMAL²⁾, 11th WLRI, Deggendorf, 1998

SLR data post processing, data averaging

Photo Number Estimate Indoor Calibration Tests

- compensated versus un-compensated output
- shot by shot data processing
- PET4 timing, NdYAG 32 ps @ 532 nm, indoor



- data spread ~ 50 ps rms
- => **ultimate photon number resolution 3 x**

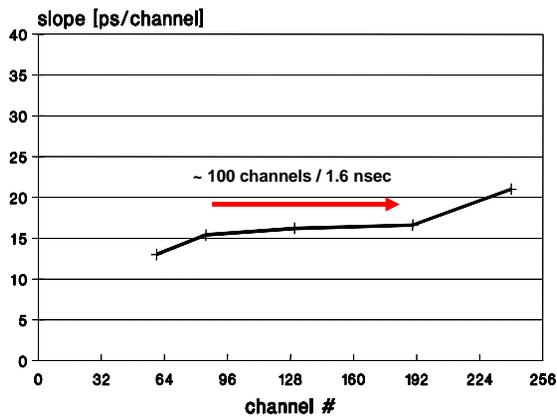
J. Blazej et al, NIST-ARDA Workshop on Single Photon Detectors, NIST, Washington DC, 2003

1 PE 10 PE 100 PE 1000 PE

Time to Digital Converter for C-SPAD Based Energy Monitor

- REQUIREMENTS:
 - resolution 20 ps
 - range 8 bits / ~ 1.6 ns
 - dead time < 400 us
- DESIGNED CIRCUIT
 - time expander, capacitor charge / discharge
 - expansion factor ~ 2000 x
 - digital counter 30 / 15 ns on Programmable Gate Array

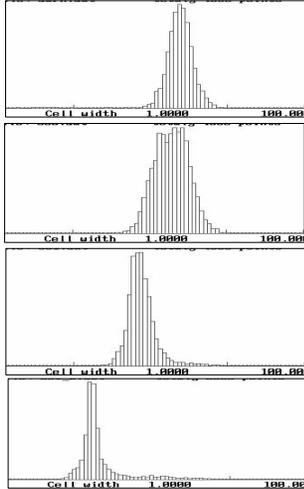
Time to Digital Converter Calibration



I.Prochazka, May 25, 2004

Indoor Laser Ranging Test

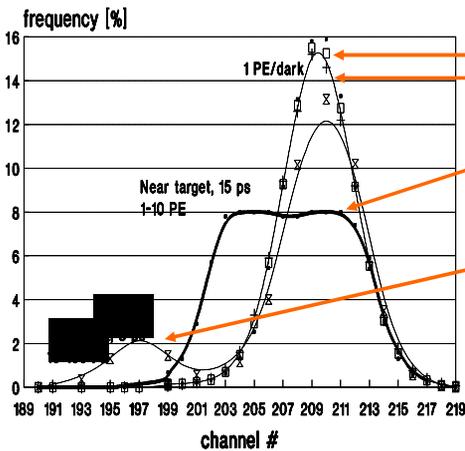
Prague, June 2, 2004, 2 kHz, 32 ps laser diode, C-SPAD, PET2k



- 1 PE 23 ps rms
dark count
- 1 ~ 10 PE 23 ps
- ~ 100 PE 12 ps
- ~ 1000 PE 8 ps

Ground Target Laser Ranging Energy Spectrum

Graz, May 5, 2004, 2 kHz, 8 ps laser, C-SPAD, PET2k



- dark counts / stability
- 2 series, 24 hours apart
- 1 m ground target ranging
1 - 10 PE, 15 ps rms
- 4 km ground target ranging
~ 1000 PE, 6 ps rms

Conclusion

- the C-SPAD based receiver package energy monitor has been constructed and tested
- FEATURES:
 - built in the PET2k
 - 7 energy levels resolution / shot - by - shot
1-3, 3-10, 10-30, 30-100, 100-300, 300-1000, > 1000
 - self - calibrating /via dark counts on 1 PE/
 - temperature & temporal stability < 0.1 ch / day
- STAND BY device of the C-SPAD energy monitor has been constructed and is available for SLR stations operating C-SPAD

